EPA/600/R-02/029

Decision-Support Tools for Predicting the Performance of Water Distribution and Wastewater Collection Systems

by

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Contract GS-23F-9737H

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Notice

The U.S. Environmental Protection Agency, through its Office of Research and Development, funded the research described here under Contract No. GS-23F-9737H to Logistics Management Institute. It has been subjected to the Agency's peer and administrative review, and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Foreword

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for reducing risks from threats to human health and the environment. The focus of the Laboratory's research program is on methods for the prevention and control of pollution to air, land, water and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites and ground water; and prevention and control of indoor air pollution. The goal of this research effort is to catalyze development and implementation of innovative, cost-effective environmental technologies; develop scientific and engineering information needed by EPA to support regulatory and policy decisions; and provide technical support and information transfer to ensure effective implementation of environmental regulations and strategies.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

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Abstract

Water and wastewater infrastructure systems represent a major capital investment; utilities must ensure they are getting the highest yield possible on their investment, both in terms of dollars and water quality. Accurate information related to equipment, pipe characteristics, location, site conditions, age, hydraulic rates, and water quality is critical to industry and municipalities to enable the most cost-efficient operation, maintenance, and rehabilitation of existing systems. This report summarizes information on European efforts to optimize operation, maintenance, and rehabilitation activities related to water distribution and wastewater collection systems. The report includes a description of:

- the capabilities and the data required to run eight pipe assessment software applications or models,
- the infrastructure performance indicators used by three European water authorities, and
- an approach to collect the necessary performance indicator (PI) data, based on our assessment of the European experience.

Based on the review and analysis of European research and product literature related to the use of models for rehabilitation management, there does not appear to be a widespread use of modeling applications in Europe. Each model presented in this report has been applied in selected urban or rural water services but not on a large national scale. UtilNets is the most comprehensive model. It contains capabilities to model pipe failures, water quality, and rehabilitation scenarios. However, it is only in the prototype development stage. The concept of modeling the impact of pipe failures on water quality and using that information for rehabilitation planning has not yet been implemented in practice. Only the EPAREL/EPANET and UtilNets models have integrated a water quality module.

Data collection costs associated with using models are high; accordingly, water services must avoid the collection of unnecessary data. The minimum data elements required by the models to develop a prioritized list of pipes based on risk of failure include: pipe material, pipe age, section length, number of breaks or bursts, and diameter. Additional information such as location, date and nature of last break, type and cost of rehabilitation options, and type of customers that would be affected by a service interruption, is necessary if managers are to assess the impact of different rehabilitation scenarios.

Spatial analysis plays an important role in rehabilitation planning since the research shows that a significant number of failures appear in geographic clusters. However, only four of the models (i.e., AssetMap, Gemini VA, KureCad and UtilNets) integrated a geographic information system (GIS) user interface.

Based on a review of three case studies and European research papers related to the use of performance indicators, it was found that the practice of using performance indicators as a management tool is not widespread or standardized across European countries. Only the UK is using a well-defined and nationally standardized approach. However, even in the UK, there has been no study of the costs of additional data collection versus the benefits of additional system serviceability. The PIs used in the case studies varied considerably, but could be grouped into indicators of: network type and size; customer service; water distribution system effectiveness and reliability; wastewater collection system effectiveness and reliability; environmental impact; and infrastructure construction and rehabilitation cost-effectiveness. The performance measurement system in the UK was found to be the most developed and could serve as a model for the US. Although all of the case studies provided examples of how PIs could be used for intra-system and inter-system comparisons, only the UK's OFWAT uses PIs to approve rehabilitation plans and price rate changes. A private water authority must demonstrate via PIs how its rehabilitation plans will improve the distribution or collection systems' serviceability to customers.

Based on the finding of this study, it is recommended that a web-based survey of industry, state and local government officials, and academic and professional groups be developed. The purpose of the survey would be to select the most important performance indicators, create uniform definitions, and verify the core data elements necessary to support the selected indicators. The results from the web survey could serve as a basis to convene an expert steering committee to provide direction to the development, fielding and use of the database. Participation should include representatives of industry, local government and water authorities. Once uniform definitions are developed, volunteer water authorities should be solicited to collect the data necessary to develop a statistically significant database of infrastructure performance indicators.

Acknowledgments

For its review of operation and maintenance practices related to the use of decision-support tools, the LMI study team obtained information from the European Cooperation in the field of Scientific and Technical Research (COST) C3 group that addresses the diagnosis of urban infrastructure. In addition, the research was based on review of current European technical literature, case studies, and interviews with European and United States practitioners. The LMI study team consisted of Mr. Steve Stone, P.E., Mr. Emil J. Dzuray, Ms. Deborah Meisegeier, Ms. AnnaSara Dahlborg, and Ms. Manuela Erickson. We would like to acknowledge and express appreciation to Dr. Peter Stahre, Dr. Sveinung Saegrov, Dr. Paul Conroy, Dr. Gerald Jones, Prof. Dr.-Ing. Raimund Herz, and Mr. Keith Edwards who helped refine the scope of this study, provided research materials and provided an overview of key issues in the European infrastructure management community. In addition to these European experts, we would like to express our appreciation to Mr. Michael R. Caprara, Project Manager, American Water Works Association Research Foundation for his assistance in identifying appropriate research documentation.

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Abbreviations

ABS	acrylonitrile-butadiene-styrene
AWWARF	American Water Works Association Research Foundation
COST	Cooperation in the field of Scientific and Technical (Research)
CPVC	chlorinated PVC
DWI	Drinking Water Inspectorate
EA	Environment Agency
USEPA	U.S. Environmental Protection Agency
ESW	East Scotland Water
EU	European Union
GIS	geographic information system
IRR	incident ratio rate
MOU	memorandum of understanding
O&M	operations and maintenance
OFWAT	Directorate General of Water Service
OM&R	operations, maintenance, and rehabilitation
PB	polybutylene
PE	polyethylene
PI	performance indicator
PVC	polyvinyl chloride
R&D	research and development
SDWA	Safe Drinking Water Act
VAV	Swedish Association of Water and Sewage Works